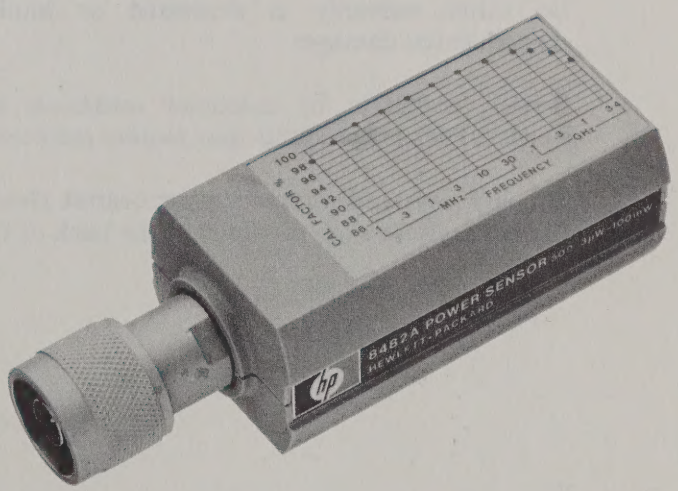
OPERATING AND SERVICE MANUAL

POWER SENSOR

8482A



HEWLETT hp PACKARD

HP 8482A

CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facilities, or to the calibration facilities of other International Standards Organization members.

WARRANTY AND ASSISTANCE

This Hewlett-Packard product is warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery. Hewlett-Packard will repair or replace products which prove to be defective during the warranty period provided they are returned to Hewlett-Packard. No other warranty is expressed or implied. We are not liable for consequential damages.

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SERIAL NUMBERS

This manual applies directly to instruments with serial numbers prefixed 1422A.

For additional important information about serial numbers, see paragraph on INSTRUMENTS COVERED BY MANUAL.

MANUAL PART NO. 08482-90001
Microfiche Part No. 08482-90002

Printed: JULY 1974

1. INTRODUCTION

2. This Operating and Service Manual contains information about incoming inspection, performance tests, adjustments, operation, troubleshooting and repair of the Model 8482A Power Sensor.

3. On the title page of this manual below the manual part number is a "Microfiche" part number. This number can be used to order a 4 x 6-inch microfilm transparency of the manual.

4. Instruments Covered by Manual

5. This instrument has a two-part serial number. The first four digits and the letter comprise the serial number prefix. The last five digits form the sequential suffix that is unique to each instrument. The contents of this manual apply directly to instruments having the same serial number prefix(es) as listed under SERIAL NUMBERS on the title page.

6. An instrument manufactured after the printing of this manual may have a serial prefix that is not listed on the title page. This unlisted serial prefix indicates that the manual for this instrument is supplied with a yellow Manual Changes supplement that contains "change information" that documents the differences.

7. In addition to change information, the supplement may contain information for correcting errors in the manual. To keep this manual as current and accurate as possible, Hewlett-Packard recommends that you periodically request the latest Manual Changes supplement. The supplement for this manual is keyed to this manual's print date and part number, both of which appear on the title page. Complimentary copies of the supplement are available on request from your nearest Hewlett-Packard office.

8. For information concerning a serial number prefix not listed on the title page or in the Manual Changes supplement, contact your nearest Hewlett-Packard office.

9. Description

10. The Power Sensor, in conjunction with a compatible power meter (such as the HP Model 435A), is designed to measure average power from −35 to +20 dBm, (≈0.3 μW to 100 mW) into a 50 ohm load at frequencies between 100 kHz and 4.2 GHz.

11. CAL FACTOR data is provided on a label attached to the Power Sensor's cover. Maximum uncertainties of the CAL FACTOR data are listed in Table 2.

Table 1. Specifications

Frequency Range: 100 kHz to 4.2 GHz.

Maximum SWR (Reflection Coefficient):

1.6 (<0.231)	100 kHz to 300 kHz
1.2 (<0.091)	300 kHz to 1 MHz
1.1 (<0.048)	1 MHz to 2 GHz
1.3 (<0.13)	2 GHz to 4.2 GHz

RF Impedance: 50 ohms nominal.

Maximum Average Power: 300 mW.

Maximum Peak Power: 15W.

Maximum Energy Per Pulse: 30 W-μs

RF Connector: Type N Male.

Power Sensor Calibration: Cal Factor data individually calibrated for each power sensor.

Dimensions (includes RF Connector): 30mm wide, 38 mm high, 105 mm long (1-3/16 x 1-1/2 x 4-1/8 in.).

Weight: Net, 0.2 kg (6 oz.)

Table 2. Uncertainty of Calibration Factor Data

Frequency	Sum of Uncertainties[1]	Probable Uncertainty[2]
0.1 MHz	± 1.85%	±1.33%
0.3 MHz	± 1.85%	±1.33%
1.0 MHz	± 1.85%	±1.33%
3.0 MHz	± 1.85%	±1.33%
10.0 MHz	± 1.85%	±1.33%
30.0 MHz	± 1.85%	±1.33%
50.0 MHz	± 1.45%	±1.03%
100.0 MHz	± 2.95%	±1.58%
300.0 MHz	± 2.95%	±1.58%
1.0 GHz	± 2.95%	±1.58%
2.0 GHz	± 3.45%	±1.92%
4.0 GHz	± 2.95%	±1.58%

1. Includes uncertainty of reference standard and transfer uncertainties. Directly traceable to NBS.

2. Square root of the sum of the individual uncertainties squared (RSS).

12. Recommended Test Equipment

13. Table 3 lists the test equipment recommended to check, adjust and repair the Model 8482A. If substitute equipment is used it should meet or exceed the listed critical specifications.

14. INSTALLATION

15. Initial Inspection

16. Inspect the shipping container for damage. If the shipping container or packing material is damaged it should be kept until the contents of the shipment have been checked mechanically and electrically. If there is mechanical damage or if the instrument does not pass the performance tests, notify the nearest Hewlett-Packard office. Keep the damaged shipping materials (if any) for the carrier and a Hewlett-Packard representative to inspect. The HP office will arrange for repair or replacement without waiting for claim settlement.

17. Storage and Shipment

18. Environment. The instrument should be stored in a clean, dry environment. The following environmental limitations apply to both storage and shipment:

Table 3. Recommended Test Equipment

Instrument Type	Critical Specifications	Suggested Model	Use*
Digital Voltmeter	Range: 100 mVdc to 100 Vdc Input impedance: 100 M-ohm Resolution: 4-digit Accuracy: ± 0.05% ± 1 digit	HP 3439A/3443A	T
Oscilloscope	Bandwidth: dc to 50 MHz Sensitivity: Vertical, 0.2V/div. Horizontal, 1 ms/div.	HP 180A/1801A/ 1821A	A, T
10:1 Divider Probe	10 M-ohm 10 pF	HP 10004B	A
Ohmmeter	Range: 1 ohm to 100 k-ohm Accuracy: ±5%	HP 412A	T
DC Power Supply	Range: 0—20 Vdc Load Regulation: 0.01% +4 mV	HP 6204B	T

*A = Adjustment; T = Troubleshooting

a. Temperature —40 to +75° C

b. Humidity, less than 95% relative

c. Altitude, less than 25,000 feet.

19. Packaging. The following general instructions should be used for re-packaging with commercially available materials:

a. Wrap the instrument in heavy paper or plastic. If shipping to a Hewlett-Packard office or service center, attach a tag indicating the type of service required, return address, model number, and full serial number.

b. Use a strong shipping container. A double-wall carton made of 200 pound test material is adequate.

c. Use enough shock-absorbing material around all sides of the instrument to provide firm cushion and prevent movement inside the container.

d. Seal the shipping container securely.

e. Mark the shipping container FRAGILE to assure careful handling.

20. Interconnections

21. Refer to the power meter operating and service manual for interconnecting instructions.

22. OPERATION

23. Environment

24. The operating environment of the 8482A should be within the following limitations:

a. Temperature 0 to 55° C

b. Humidity, less than 95% relative

c. Altitude, less than 15,000 feet.

25. Operating Precautions

26. Precautions must be taken not to exceed the maximum allowable RF input level for the 8482A. Refer to the operation section of the power meter manual for operating instructions pertaining to the complete power meter system.

CAUTIONS

The maximum RF voltage which may be safely coupled to this Power Sensor is 3.87 Vrms. Exceeding this limit may damage the Power Sensor, power meter, or both.

BEFORE CONNECTING THE POWER SENSOR TO ANOTHER INSTRUMENT, ensure that the instrument and power meter are connected to the protective (earth) ground.

Exceeding the energy and power levels shown in Figures 1, 2, and 3 may result in damage to the power meter system.

27. The absolute maximum RF signal level that may be coupled to the 8482A Power Sensor is:

a. Maximum Average Power . . . 300 mW

b. Maximum Peak Power . . . . . 15 W

c. Maximum Energy Per Pulse . 30 W-μs

28. Figure 1 expresses the absolute maximum energy input in graphical form. Figures 2 and 3 show the maximum levels that may be indicated by the power meter, as they relate to pulse repetition frequency (PRF) and duty cycle, and still be within the allowable energy levels expressed in Figure 1.

29. SWR (REFLECTION COEFFICIENT) PERFORMANCE TEST

30. Description. To verify the Power Sensor's SWR and reflection coefficient specifications, use any system whose measurement uncertainties for SWR are equal to or less than those listed in the following table.

Frequency	System SWR Uncertainty	Actual Measurement	Maximum SWR (Reflection Coefficient)
100 kHz to 300 kHz	± 0.08	_____	1.6 (<0.231)
300 kHz to 1 MHz	± 0.04	_____	1.2 (<0.091)
1 MHz to 2 GHz	± 0.02	_____	1.1 (<0.048)
2 GHz to 4.2 GHz	± 0.02	_____	1.3 (<0.13)

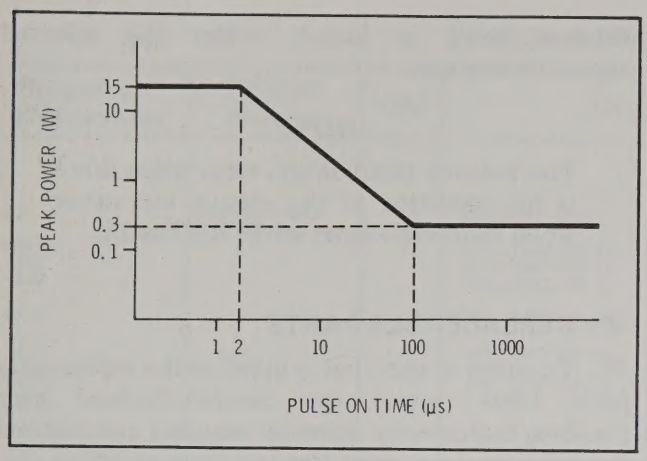

Figure 1. Maximum Energy Input to Power Sensor

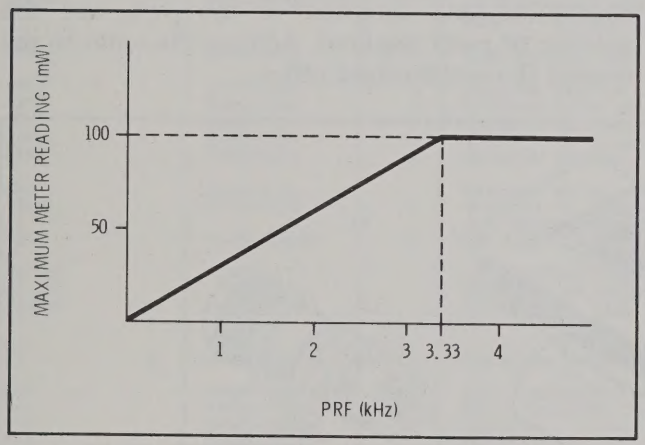

Figure 2. Maximum Power Reading vs Pulse Repetition Frequency (Pulse Width <100 µs)

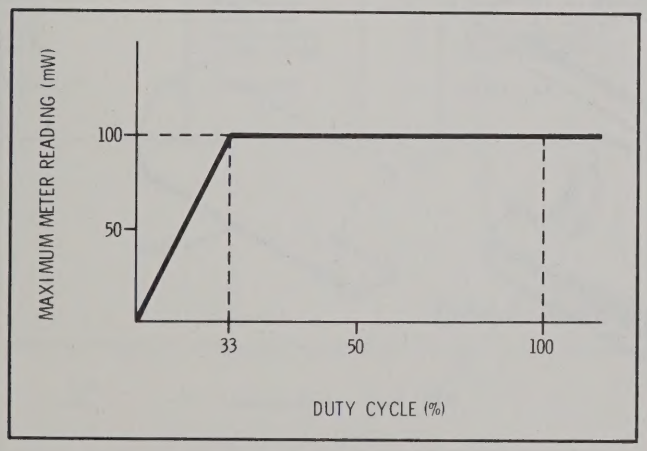

Figure 3. Absolute Maximum Power Meter Reading vs Duty Cycle (Pulse Width >100 µs)

31. FET BALANCE ADJUSTMENT

NOTE

A2C2 and A2C7 are factory selected components and are identified on the schematic and parts list with an asterisk (*). (Only one of the two capacitors or possibly neither capacitor will be in the circuit.) The nominal value is shown but the actual value and part number may be different.

32. Description. If the A2A1 FET Assembly is replaced, it may be necessary to change the value of A2C2 or A2C7. The selected capacitor is used to balance the gate-to-drain capacitance of one FET to that of the other FET. This balances the Sampling Gate circuitry and reduces the amplitude of switching transients (spikes). The transient amplitude is monitored with an oscilloscope while the capacitors and capacitor values are changed. The selection procedure is complete when the transient amplitude is minimized. The capacitor will be coupled across the gate and drain leads of the FET with the lower capacitance.

NOTE

Transient amplitude is also affected by the relative positions of the 90 (white/black) and 91 (white/brown) wires which connect the A2 assembly and J1. Minor adjustments to the amplitude can be made by repositioning these wires. Therefore, it is important that their positions are not disturbed once minimum transient amplitude is attained.

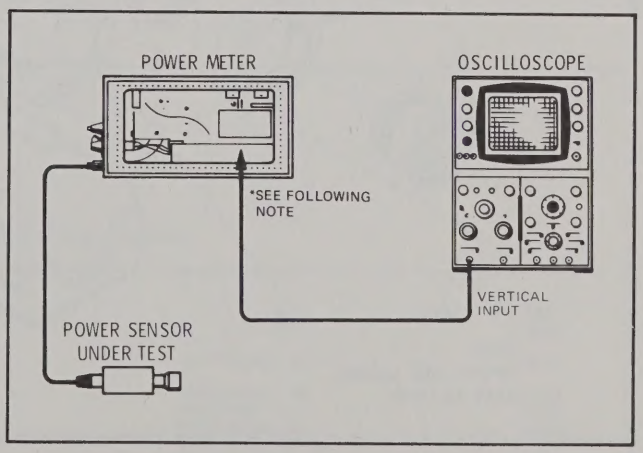

Figure 4. FET Balance Equipment Setup

NOTE

The correct test point for monitoring transient spikes is located at the output of the last ac amplifier of the power meter. (For the HP Model 435A, use A4TP4.)

33. Equipment. Any oscilloscope whose specifications meet or exceed the critical specifications listed in Table 3 for HP 180A/1801A/1821A should be used.

34. Procedure. Connect the equipment as shown in Figure 4. Set the power meter range control to 3 μW. Check the amplitude of the switching transients (spikes) on the oscilloscope display. If A2C2 or A2C7 is in the circuit, vary its value between 1 and 10 pF until the balance point (minimum spike amplitude) is found. If the balance point is not reached, remove the capacitor and follow the same procedure using the other capacitor location (A2C2 or A2C7). When the balance point is found, solder the selected capacitor in place.

NOTE

The balance point might exist when there is no capacitor in the circuit but never when both capacitors are in the circuit.

35. REPLACEABLE PARTS

36. To order a part that is listed in the replaceable parts table, quote the Hewlett-Packard part number, indicate the quantity required and address the order to the nearest Hewlett-Packard office.

37. To order a part that is not listed in the replaceable parts table, include the instrument model number, instrument serial number, the description and function of the part, and the number of parts required. Address the order to the nearest Hewlett-Packard office.

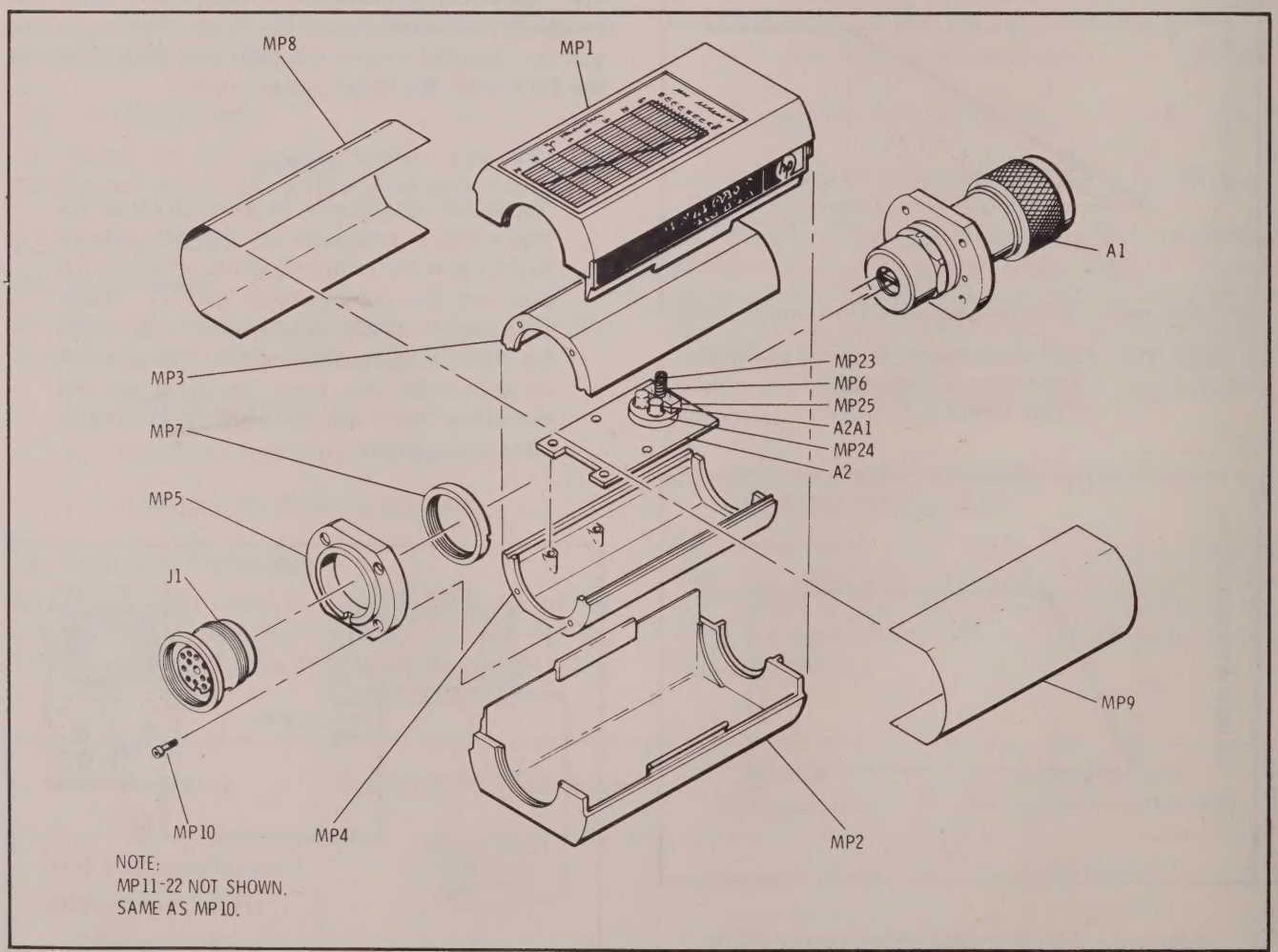

Figure 5. Illustrated Parts Breakdown

Table 4. Replaceable Parts

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1	08482-60003	1	BULKHEAD ASSY	28480	08482-60003
A1C1			NSR, PART OF A1		
A1C2			NSR, PART OF A1		
A1C3			NSR, PART OF A1		
A1J1			NSR, PART OF A1		
A1R1			NSR, PART OF A1		
A1TC1			NSR, PART OF A1		
A2	08482-60001	1	INPUT AMPLIFIER ASSY	28480	08482-60001
A2C1	0180-0555	1	CAPACITOR-FXD 39UF +-20% 10VDC TA-SOLID	12954	D39GS1B10M
A2C2*	0160-3872	2	CAPACITOR-FXD 2.2PF +-.25PF 200WVDC CER (SEE FET BALANCE ADJUSTMENT)	28480	0160-3872
A2C3	0180-2515	1	CAPACITOR-FXD; 47UF+-20% 6VDC TA-SOLID	56289	196D476X0006KA1
A2C4	0160-3094	1	CAPACITOR-FXD .1UF +-10% 100WVDC CER	28480	0160-3094
A2C5	0160-3879	1	CAPACITOR-FXD .01UF +-20% 100WVDC CER	28480	0160-3879
A2C6	0180-2545	1	CAPACITOR-FXD; 100UF+-20% 4VDC TA-SOLID	56289	196D107X0004KE3
A2C7*	0160-3872		CAPACITOR-FXD 2.2PF +-.25PF 200WVDC CER (SEE FET BALANCE ADJUSTMENT)	28480	0160-3872
A2Q1	1854-0610	1	TRANSISTOR:SI NPN	28480	1854-0610
A2R1	0757-0483	1	RESISTOR 562K 1% .125W F TUBULAR	30983	MF5C1/8-T0-5623-F
A2R2	0698-7248	1	RESISTOR 3.16K 2% .125W F TUBULAR	24546	C3-1/8-T0-3161-G
A2R3	0698-7236	3	RESISTOR 1K 2% .125W F TUBULAR	24546	C3-1/8-T0-1001-G
A2R4	0698-7236		RESISTOR 1K 2% .125W F TUBULAR	24546	C3-1/8-T0-1001-G
A2R5	0698-7224	1	RESISTOR 316 OHM 2% .125W F TUBULAR	24546	C3-1/8-T0-316R-G
A2R6	0698-7236		RESISTOR 1K 2% .125W F TUBULAR	24546	C3-1/8-T0-1001-G
A2R7	0811-3210	1	RESISTOR 31.6 OHM 5% 0.5W PWW TUBULAR (POS TEMPERATURE COEF 0.5%/°C)	14140	1409-1/20-31R6-J
A2A1	08481-60002	1	FET ASSY	28480	08481-60002
A2A1Q1			NOT ASSIGNED		
A2A1Q2			NSR, PART OF A2A1.		
A2A1Q3			NSR, PART OF A2A1.		
J1	1251-3228	1	CONNECTOR, 12-CONT, FEM, CIRC AUDIO	28480	1251-3228
MP1	08481-40002	2	SHELL, PLASTIC	28480	08481-40002
MP2	08481-40002		SHELL, PLASTIC	28480	08481-40002
MP3	08481-20011	2	CHASSIS	28480	08481-20011
MP4	08481-20011		CHASSIS	28480	08481-20011
MP5	08481-20008	1	ENDBELL	28480	08481-20008
MP6	1460-1330	1	SPRING; COMPRESSION; CYLINDER	28480	1460-1330
MP7	1251-3363	1	NUT:CONNECTOR MOUNTING	28480	1251-3363
MP8	08481-00002	2	SHIELD	28480	08481-00002
MP9	08481-00002		SHIELD	28480	08481-00002
MP10 THRU MP22	3030-0422	13	SCREW-SKT HD CAP 0-80 HD HEX REC SST	28480	3030-0422
MP23	3030-0436	1	SCREW-SKT HD CAP 0-80 HD HEX REC SST	28480	3030-0436
MP24	08481-40003	1	SPACER, FET	28480	08481-40003
MP25	08481-40004	1	CLAMP LEAD	28480	08481-40004
MP26	7120-4199	1	LABEL, ID	28480	7120-4199

Table 5. Code List of Manufacturers

MFR NO.	MANUFACTURER NAME	ADDRESS	ZIP CODE
12954	DICKSON ELECTRONICS CORP	SCOTTSDALE AZ	85252
14140	EDISON ELEK DIV MCGRAW-EDISON	MANCHESTER NH	03130
24546	CORNING GLASS WORKS	BRADFORD PA	16701
28480	HEWLETT-PACKARD CO CORPORATE HQ	PALO ALTO CA	94304
30983	MEPCO/ELECTRA CORP	SAN DIEGO CA	92121
56289	SPRAGUE ELECTRIC CO	NORTH ADAMS MA	01247

38. SERVICE

39. Test equipment that meets or exceeds the critical specifications on Table 3 may be used in place of the recommended instruments for troubleshooting the 8482A.

40. Figure 6 shows the locations of the assemblies and components of the Model 8482A and Figure 7 is the schematic diagram.

41. Principles of Operation

42. The thermocouples contained in the Model 8482A present a 50-ohm load to the RF signal coupled into the Power Sensor. As the RF signal is dissipated by the thermocouples, they generate a dc voltage that is proportional to the RF input power. This dc output is coupled to the FET sampling gate (chopper) circuit where it is sampled at a 220 Hz rate. The gate circuit output is therefore a 220 Hz ac signal whose amplitude is proportional to the RF input power. The ac signal is amplified approximately 750 times by a hybrid operational amplifier made up of the power meter's first amplifier and the Input Amplifier of the 8482A. Figure 9 is a simplified diagram showing the hybrid operational amplifier circuit configuration.

43. The Auto Zero Feedback circuit is coupled to the Power Sensor from the power meter. The dc voltage used to set the zero level is coupled across the input to the FET's by using A2R1, A1R1, and the series resistance (200 ohms) of the thermocouple A1TC1 as a voltage divider network.

44. Troubleshooting

45. It will be necessary to disassemble the Power Sensor to make the following measurements. Refer to Disassembly Procedures for important information and precautions.

46. A1 Bulkhead Assembly. The A1 assembly output is normally +12 ±3 mVdc with a 100 mW input. Resistance measured across two gold wires leading to A2 assembly should be 245 ± 12.5 ohms. (Excessive power will damage the thermocouples and cause their resistance to increase.) If the A1 Bulkhead Assembly is defective, the entire Bulkhead Assembly must be replaced.

CAUTION

Be extremely careful when measuring across the gold wires; they are delicate and may be easily damaged.

47. Gate Drive. The multivibrator drive from the Power Sensor to the FET Sampling Gate circuit may be checked at the FET metal case. This drive voltage is a 220 Hz square wave whose positive level is −0.05 ± 0.05 Vdc and negative level is >9V more negative.

48. Hybrid Operational Amplifier. In most cases it may be assumed that the operational amplifier, made up of the Input Amplifier and the first amplifier in the power meter is operating correctly if the dc voltage found on the metal case of A2Q1 is −70 ± 30 mVdc.

49. A2A1 FET Assembly. FET's A2A1Q2 and Q3 may be checked by measuring source-drain resistance while biasing the FET's on and off.

a. Remove the power sensor cable from the 8482A.

b. Remove the upper chassis of the 8482A. See Upper Chassis Removal.

c. Set the output of a dc power supply to 10V.

d. Connect the positive lead of the power supply to the positive side of A2C3.

e. Connect one lead from an ohmmeter to the power supply positive lead and the other to chassis ground. Verify the resistance is less than 40 ohms.

f. Bias both FET's off by connecting the negative power supply lead to both FET metal cases (gates). If the resistance increases:

1) <10 ohms, A2A1Q3 is probably defective.

2) 200 to 300 ohms, A2A1Q2 is probably defective.

3) several hundred times, both FET's are functioning properly.

NOTES

1. If either FET is defective, the entire A2A1 FET Assembly must be replaced.

2. If the FET's are replaced, it is recommended that the FET Balance Adjustment be performed in order to bring the 8482A to its maximum operating capability.

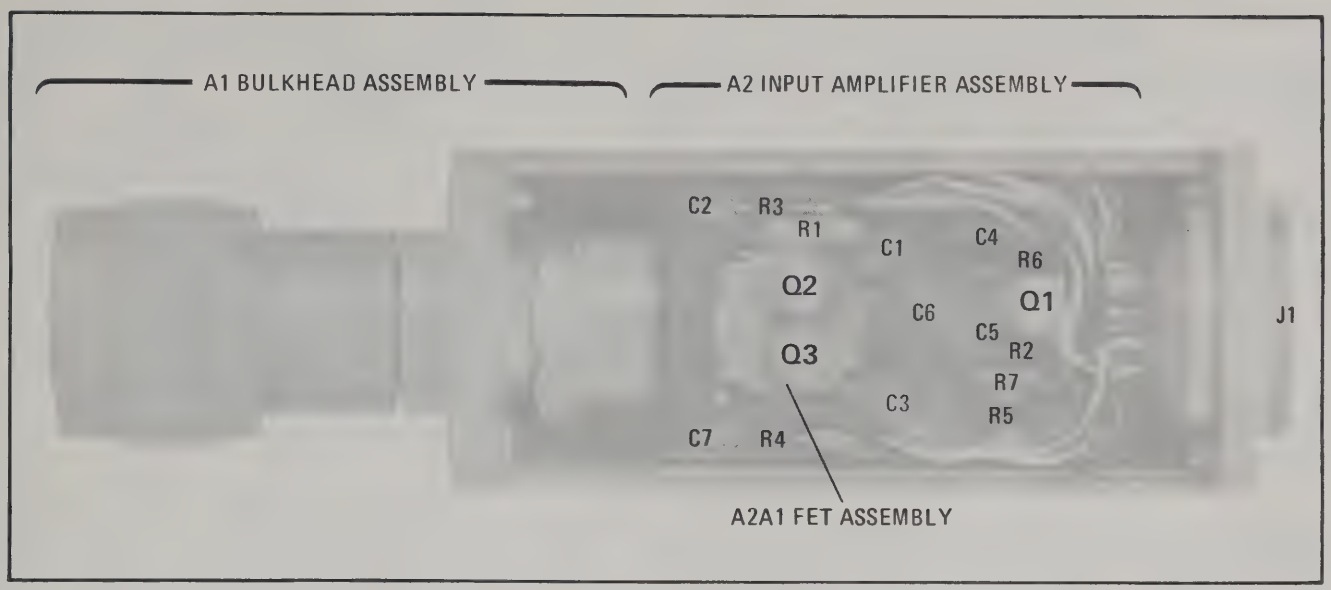

Figure 6. Model 8482A Assembly and Component Locations

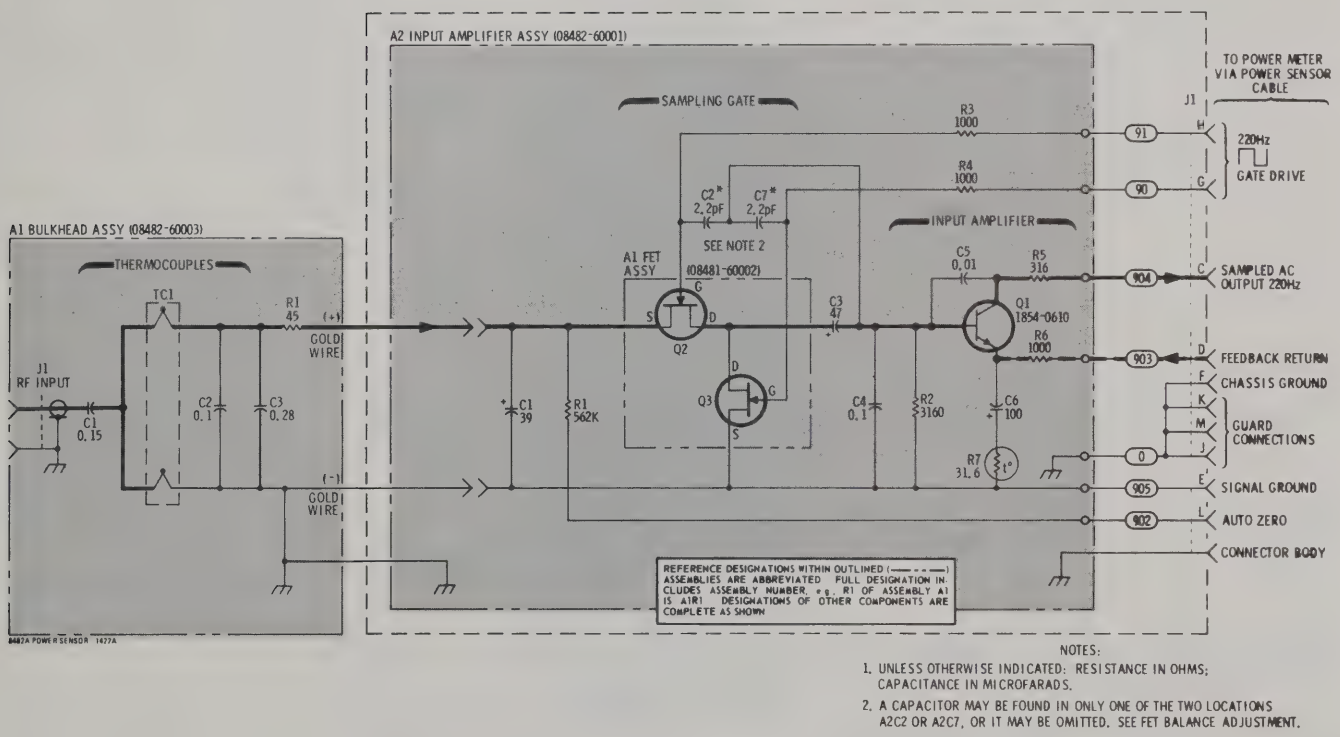

Figure 7. Model 8482A Schematic Diagram

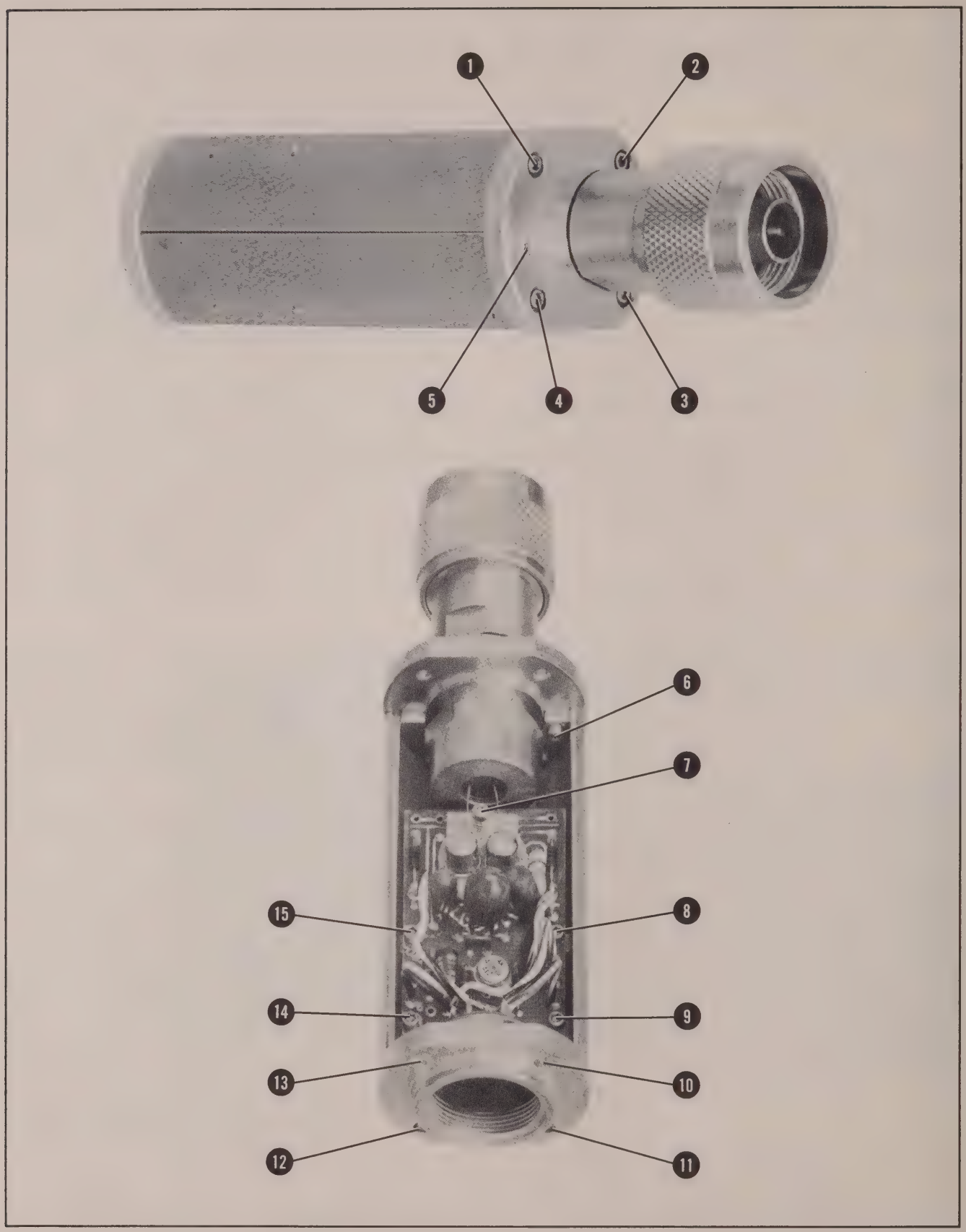

Figure 8. Power Sensor Hardware Locations

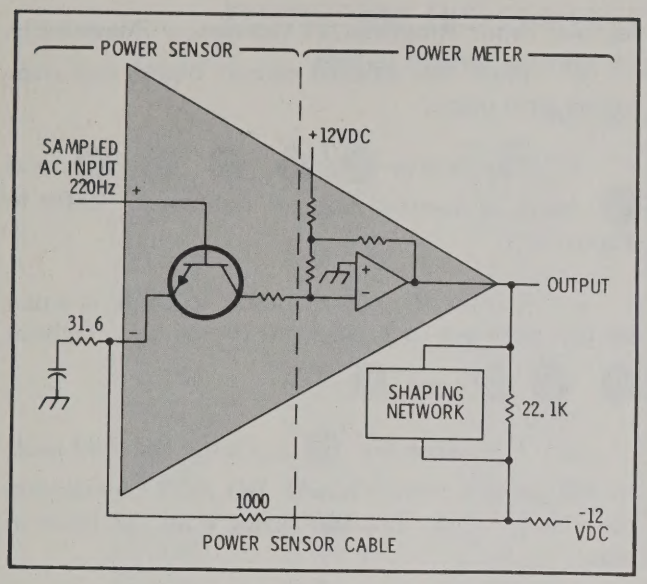

Figure 9. Hybrid Operational Amplifier

50. Disassembly Procedures

51. The upper chassis removal should always be done first to avoid damaging the gold wires connecting the A1 Bulkhead Assembly and the A2 Input Amplifier Assembly. (If the gold wires are damaged the Bulkhead Assembly must be returned to the factory for repair.) Then either the A1 Bulkhead Assembly or the A2 Input Amplifier Assembly may be removed. FET Assembly removal should take place after A2 assembly removal.

CAUTION

The gold wires connecting the A1 Bulkhead Assembly and the A2 Input Amplifier Assembly are extremely delicate and may be easily broken. Be careful when working around them.

52. Upper Chassis Removal

a. Insert the blade of a small screwdriver between the two-piece plastic shell at the rear of the Power Sensor. Gently pry the sections apart.

b. Proceed to the other side of the connector and again pry the cover sections apart. Remove the shells and magnetic shields.

c. Position the Power Sensor as shown in Figure 8 (top). The small hole ❺ should be on the left side of the RF input connector. Remove the allen cap screws ❶, ❷, ❿, and ⓭. Loosen ⓫ and ⓬. Remove the upper chassis from the Power Sensor.

53. A1 Bulkhead Assembly Removal

a. Remove the spring clamp cap screw ❼ to free the gold leads which come from the Bulkhead Assembly.

b. Remove cap screws ❸, ❹, and ❻.

c. Slide the Bulkhead Assembly straight out from the chassis.

54. A2 Input Amplifier/J1 Connector Removal

a. Remove the spring clamp cap screw ❼ to free the gold leads which come from the Bulkhead Assembly.

b. Remove cap screws ❽, ❾, ⓫, ⓬, ⓮ and ⓯.

c. Slide the A2 Input Amplifier and J1 connector straight out from the chassis.

55. FET Assembly Removal

CAUTION

Excessive heat from the soldering iron when installing or removing the assembly, may destroy the FET internal circuitry. Before removing the FET Assembly be sure that it must be replaced. The Troubleshooting information gives the correct procedures for verifying that the FET's are defective.

a. Remove the A2 Input Amplifier Assembly.

b. Remove the cap screw, compression spring, and lead clamp from the A2A1 FET Assembly.

c. Remove the adhesive bonding which covers the FET pin connectors to the printed circuit board.

d. With a desoldering tool, remove the solder from the six pins which hold the FET Assembly in place.

e. Carefully break each pin loose from the printed circuit board with a soldering aid tool.

f. Gently lift the FET Assembly and spacer from the circuit board. Refer to Figure 10.

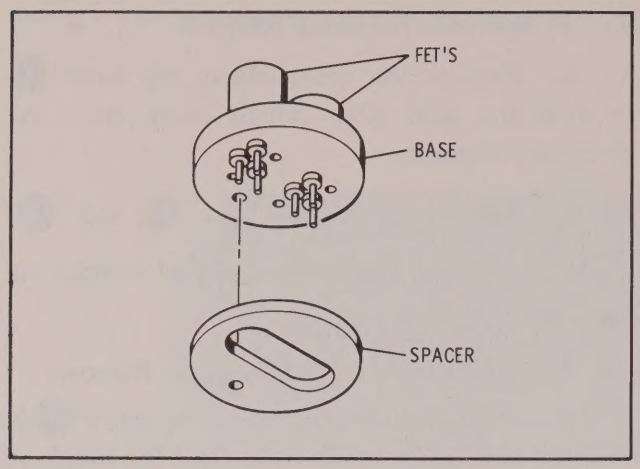

Figure 10. FET Assembly and Spacer

56. Reassembly Procedures

CAUTION

The gold wires connecting the A1 Bulkhead Assembly and the A2 Input Amplifier Assembly are extremely delicate and may be easily broken. Be careful when working around them.

57. FET Assembly Installation

a. Insert the FET Assembly leads through the spacer and printed circuit board.

b. Insert the lead clamp compression spring and cap screw to hold the spacer and assembly in place against the printed circuit board. Refer to Figure 10.

c. Solder the FET leads to the circuit board.

CAUTION

Excessive heat may damage the FET's.

d. With hypodermic needle inject adhesive bonding* into the hollow portion of the spacer. To accomplish this, insert the needle into the hole in the circuit board directly beneath the FET Assembly.

e. Cover the soldered connections of the FET Assembly with adhesive bonding.*

f. Cover the rest of the base of the A2 assembly circuit with an acrylic coating.**

58. A2 Input Amplifier/J1 Connector Reassembly

a. Slide the printed circuit board and connector into place.

b. Cap screws 8, 9, 11, 12, 14, and 15 must be inserted but not tightened. Refer to Figure 8.

c. Center the circuit board so there is equal air gap between each side and the chassis. Tighten 8, 9, 14, and 15.

d. Use cap screw 7 to clamp the gold leads to the printed circuit board. DO NOT overtighten the clamp screw. Let the spring hold the leads in place.

e. Bend A2C6 so that it touches A2Q1. Bend A2C1 and A2C3 until they touch A2C6.

59. A1 Bulkhead Assembly Reinstallation

a. Secure the Bulkhead Assembly to the chassis by inserting cap screw 6. Do not tighten the screw at this time.

b. Insert cap screws 3 and 4; tighten only cap screw 6.

c. Use cap screw 7 to clamp the gold leads to the printed circuit board. DO NOT overtighten the clamp screw. Let the spring hold the leads in place.

60. Upper Chassis Reassembly

a. The upper chassis should be placed in position and cap screws 1, 2, 10, and 13 should be inserted.

b. Tighten 1, 2, 3, and 4.

c. Tighten 10, 11, 12, and 13.

d. Place the plastic shells, magnetic shields, and the chassis together as shown in Figure 5. Snap the plastic shells together.

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*3140 RTV Coating, silicone rubber, Dow Corning Corporation, Midland, Michigan, 48640 (HP 0470-0440).

**Krylon No. 1302 Crystal Clear coating, Borden Chemicals, Krylon Dept., Norriston, Pennsylvania, or, Plastic 707, United Technical Lab, Morristown, New Jersey (HP 6010-0140).

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